

## Module 2: Foundations in Chemistry

### Atomic Structure and isotopes

$$\text{number of neutrons} = \text{mass number} - \text{atomic number}$$

$$\text{Relative atomic mass} = (\text{mass of isotope 1} \times \text{abundance of isotope 1}) + (\text{mass of isotope 2} \times \text{abundance of isotope 2}) / 100$$

### Amount of Substance

$$\% \text{ atom economy} = M_r \text{ of desired product} / \text{sum of } M_r \text{ of all products} \times 100$$

$$\% \text{ yield} = \text{actual mass} / \text{theoretical mass} \times 100$$

$$\text{moles} = \text{mass} / M_r$$

$$\text{moles} = \text{concentration} \times \text{volume} / 1000 \text{ (dm}^3\text{)}$$

$$\text{moles} = \text{volume} / 24 \text{ (dm}^3\text{) (gases) (value in data sheet)}$$

$$\text{moles} = \text{number of particles} / 6.02 \times 10^{23} \text{ (value in data sheet)}$$

$$\text{mol dm}^{-3} \times M_r \rightarrow \text{g dm}^{-3}$$

$$PV = nRT \text{ (gases) where } v \text{ is in m}^3, T \text{ is in K and } P \text{ is in Pa, } R \text{ (in data sheet)}$$

$$\text{percentage error} = \text{uncertainty in instrument} / \text{value} \times 100$$

## Physical Chemistry

### Enthalpy Changes

$$\Delta H = \text{sum of bonds broken} - \text{sum of bonds made (mean bond enthalpies)}$$

$$Q = mc \Delta T \text{ where } m = \text{mass of water, } c = 4.18 \text{ (in data sheet) and } T \text{ is in K}$$

### Reaction Rates

$$\text{Rate} = 1/\text{time}$$

$$\text{Rate} = \text{gradient of concentration-time curve}$$

## Equilibrium



$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

## Module 5: Physical Chemistry & Transition Elements

### Rates

For  $A + B \rightarrow C + D$

$$\text{rate} = k[A][B]$$

$$k = \ln 2 / t_{1/2} \quad \text{where } t_{1/2} = \text{a half-life for a 1}^{\text{st}} \text{ order reaction}$$

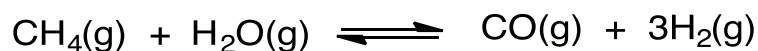
Arrhenius:

$$k = A e^{-E_a/RT}$$

$$\ln k = \ln A - E_a/RT \quad (\text{both given in data sheet})$$

### Equilibrium

Example:



$$K_p = \frac{p(\text{CO}) \times p(\text{H}_2)^3}{p(\text{CH}_4) \times p(\text{H}_2\text{O})}$$

**Mole fraction = moles of one gas / moles of all the gases**

**Partial Pressure = mole fraction x total pressure**

**Total Pressure = sum of the partial pressures**

### Acids and Bases

$$\text{pH} = -\log_{10} [\text{H}^+]$$

$$[\text{H}^+] = 10^{-\text{pH}}$$

$$K_w = [\text{H}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \text{ (at room temp) (value in data sheet)}$$

$$K_w = [\text{H}^+]^2 \text{ (pure water)}$$

**% dissociation:**  $\text{H}^+$  concentration at equilibrium/the original acid concentration  $\times 100$

Expression and use in buffer calculations:

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

Weak acid calculations:

$$K_a = \frac{[\text{H}^+]^2}{[\text{HA}]}$$

$$\text{p}K_a = -\log_{10} K_a$$

$$K_a = 10^{-\text{p}K_a}$$

## Enthalpy, Entropy & Free Energy

$$\Delta S = (\text{sum of entropy of products}) - (\text{sum of entropy of reactants})$$

$$\Delta H = (\text{sum of enthalpy of products}) - (\text{sum of enthalpy of reactants})$$

$$\Delta G = \Delta H - T\Delta S_{\text{system}}$$

$$\text{min. temp.} = \Delta H / \Delta S_{\text{system}}$$

## Electrode Potentials

$$E_{\text{cell}} = E^\ominus \text{ of the more positive value} - E^\ominus \text{ of the more negative value}$$

or

$$E_{\text{cell}} = E^\ominus \text{ of the species being reduced} - E^\ominus \text{ of the species being oxidised}$$